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(54) Separation of oil and gas phases in wellhead fluids

Trennung von Öl- und Gasphase am Bohrlochkopf

Séparation d'une phase gazeuse d'une phase d'huile à la tête de forage

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(73) Proprietor: **THE BABCOCK & WILCOX COMPANY**
New Orleans, Louisiana 70160-0035 (US)

(72) Inventors:
- **Prueter, William Paul**
  Alliance, Ohio 44601 (US)
- **Birmingham, Daniel P.**
  North Canton, Ohio 44721 (US)
- **Reed, Matthew J.**
  Canton, Ohio 44709 (US)

(74) Representative: **Pilch, Adam John Michael et al**
D. YOUNG & CO.,
21 New Fetter Lane
London EC4A 1DA (GB)

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US-A- 2 037 426
US-A- 2 256 524
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US-A- 3 324 634
US-A- 4 648 890

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Description

[0001] This invention relates in general to separation systems and, in particular, to apparatus for separating oil and gas phases contained in wellhead fluids obtained from hydrocarbon production systems.

[0002] Most of the known gas/oil separation systems rely on natural or gravity separation which requires large vessels to achieve the desired separation performance. When natural separation is used in a relatively small vessel, the throughput or vapour flux of that system is significantly smaller when compared to other systems not relying on natural separation. An example of a system which apparently uses natural separation is described in US Patent No. US-A-4 982 794.

[0003] One known separation system is disclosed in UK Patent Application No. GB-A-2 203 062 which uses centrifugal separation for a primary separation stage and inertial separation (i.e., scrubbers) for a second stage of separation. Although this system most likely has higher separation capacities than a system relying on natural separation, it most likely has less capacity when compared to a system that could employ centrifugal separation for both stages.

[0004] US Patent Nos. US-A-2 037 426, US-A-2 256 524 and US-A-2 533 977 disclose oil and gas separation systems including primary and secondary centrifugal separators for separating an oil/liquid phase from a gas phase contained in a well head fluid from a hydrocarbon production system.

[0005] According to the invention there is provided apparatus for separating an oil/liquid phase from a gas phase contained in a wellhead fluid from a hydrocarbon production system, the apparatus comprising:

> a vessel capable of pressurization and having a wellhead fluid inlet for connection to the hydrocarbon production system, for entry of wellhead fluid, a gas export outlet for exit of export gas separated from the wellhead fluid, and an oil/liquid export outlet for exit of oil/liquid separated from the wellhead fluid;
>
> a main oil/liquid inventory compartment at a lower end of the vessel, the oil/liquid export outlet communicating with the inventory compartment, a secondary compartment at an upper end of the vessel, and means for connecting the inventory and secondary compartments to each other;
>
> a primary centrifugal separator in the vessel for separating a majority of the oil/liquid phase from the wellhead fluid to leave a wet gas phase, the primary centrifugal separator comprising a riser tube with an open lower end communicating with the wellhead fluid inlet for receiving upwardly flowing wellhead fluid, the riser tube having a closed upper end, a plurality of curved-arms spaced around the riser tube for causing a majority of the oil/liquid phase to separate from the wellhead fluid to leave the wet gas phase, each curved-arm having an axially extending curved wall, curving away from the riser tube between a root edge of the curved wall at the riser tube and an outer edge of the curved wall spaced outwardly from the riser tube, at least one radial partition in the curved-arm, for dividing an inner space defined by the curved-arm into multiple levels, the primary centrifugal separator also comprising a return cylinder around the riser tube and curved-arms, for receiving oil/liquid phase moving outwardly by centrifugal force from the outer edge of the curved-arms, the return cylinder having an open lower end extending into the inventory compartment for carrying the oil/liquid phase downwardly to the inventory compartment, the return cylinder having an open upper end for passing the wet gas phase; and
>
> a secondary centrifugal separator in the vessel spaced above and axially aligned with the primary centrifugal separator by an open interstage region, the secondary centrifugal separator receiving the wet gas phase and comprising a plurality of tangential inlet vanes into which the wet gas phase passes for further separating oil/liquid from the wet gas phase to leave a dry gas phase, the secondary centrifugal separator including skimmer means defining skimmer slots above the inlet vanes for receiving the dry gas phase and for channelling the further separated oil/liquid downwardly into the secondary compartment, the further separated oil/liquid passing from the secondary compartment to the inventory compartment through the means for connecting the inventory and secondary compartments, the skimmer means having an open upper end communicating with the gas export outlet for passing the dry gas phase to the gas export outlet.

[0006] The present invention is adapted for separating a wellhead fluid mixture containing oil and gas phases obtained from hydrocarbon production systems into its constituent parts. Embodiments of the present invention can be employed either topside or in subsea applications through the use of a compact and highly efficient separator arrangement.

[0007] More particularly, one embodiment of the present invention provides a separation apparatus which utilizes one or more curved-arm, centrifugal force, primary separator(s) and one or more cyclone, centrifugal force, secondary separator(s). Except for some changes made to the curved-arms, the primary separator is preferably similar to the separator described in US Patent No. US-A-4 648 890. The secondary separator is preferably similar to the separator described in US Patent No. US-A-3 324 634. The primary and secondary separators are always employed in pairs, and the combination of a centrifugal-type primary and secondary separator provides a compact and highly-efficient separator arrangement. The separator apparatus can be

used in multiple pairs (two or more primary and two or more secondary separators) or in an apparatus having only a single primary and a single secondary separator. The multiple pair arrangement is typically used for topside applications while the single primary/single secondary separator arrangement is typically sufficient to satisfy most subsea applications.

[0008] Currently, topside or platform separation is normally performed using gravity separation which requires very large drum or pressure vessel volumes. Not only is the preferred embodiment of the present invention less costly to fabricate due to its smaller size than known separation devices, but the reduced size of the gas/oil separator thus requires less platform space, an economically attractive feature since the cost of platforms is directly related to the size of the vessels.

[0009] The preferred embodiment of the present invention also provides a unique and efficient compact apparatus for subsea separation of a gas and liquid mixture. In a subsea application, the present apparatus provides the most benefit for marginal field developments because without subsea separation, marginal fields may become economically unfeasible to operate.

[0010] As is well-known, subsea separation provides for the separation of vapour and liquid phases prior to transporting the fluids to a platform or production facility. Fewer technical challenges are involved with first separating the phases and then separately transporting them downstream as compared to transporting a multiphase mixture of gas and oil where slugging and hydrate formation issues are prevalent.

[0011] Presently, no other apparatus is known which provides a combination of centrifugal force primary and secondary separators having the compactness and high capacity separation efficiency of the present system.

[0012] The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic sectional view illustrating a first embodiment of the present invention utilizing plural primary and plural secondary centrifugal separators;

Figure 2 is a cross-sectional view taken in the direction of arrows 2-2 in Figure 1;

Figure 3 is a schematic sectional view illustrating a second embodiment of the present invention utilizing single primary and single secondary centrifugal separators;

Figure 4 is a cross-sectional view taken in the direction of arrows 4-4 in Figure 3;

Figure 5 is a close-up, perspective view of a curved-arm, primary separator and a cyclone, secondary separator embodying the present invention; and

Figure 6 is a graph plotting test results for liquid flow versus vapour flow in a centrifugal separator arrangement embodying the present invention.

[0013] Referring to the drawings generally, wherein like numerals designate the same or functionally similar elements throughout the several drawings, and to Figure 1 in particular, one embodiment of the present invention provides a compact, high-efficiency, multiple pair, centrifugal gas/oil separator apparatus 10 for separating wellhead fluids 12 obtained from hydrocarbon production systems into separate oil and gas phases. As used herein, the term wellhead fluid means any two-phase mixture of oil and gas substantially in its natural state as extracted from the earth, or as transported from its extraction point to the gas/oil separator of the present system.

[0014] The gas/oil separator 10 comprises a drum or pressure vessel 14 having a wellhead fluid inlet 16 for providing the wellhead fluids 12 (typically crude oil and entrained gases) into the pressure vessel 14. A gas export outlet 18 is located at an end opposite the fluid inlet 16 of the pressure vessel 14 for conveying separated gases 20 from the pressure vessel 14. The pressure vessel 14 includes an oil/liquid export outlet 22 for conveying separated oil/liquids 24 from the pressure vessel 14. As shown in Figure 1, the pressure vessel 14 is oriented substantially vertically, with the wellhead fluid inlet 16 located generally at a lower end thereof, the gas export outlet 18 located at an upper end thereof, and the liquid export outlet 22 located at some intermediate location.

[0015] The oil/gas separator 10 employs multiple pairs of centrifugal force separators, in particular, one or more curved-arm, centrifugal force, primary separator(s) 30 and one or more cyclone, centrifugal force, secondary separator(s) 50. Since these primary and secondary separators 30, 50 are similar to those described in the aforementioned US Patent Nos. US-A-4 648 890 and US-A-3 324 634, the reader is referred to these references as needed for specific details. The primary and secondary separators 30, 50 are always employed in pairs, and the combination of a centrifugal-type primary and secondary separator provides a compact and highly-efficient separator arrangement. The wellhead fluids 12 are first acted upon by the curved-arm, centrifugal force, primary separator(s) 30 which perform a first centrifugal force separation of oil/liquids 26 from the two-phase wellhead fluids 12, producing a wet gas 28 with some remaining oil/liquid 29 therein. Then, the cyclone, centrifugal force, secondary separator(s) 50, located above and paired together with the curved-arm, centrifugal force, primary separator(s) 30, perform a second centrifugal force separation operation on the wet gas 28 leaving the primary separator(s) 30, from which a majority of the liquid has been removed, to remove as much of the remaining oil/liquid 29 from the wet gas 28 as possible.

[0016] Over 95 percent of the liquid in the wellhead fluids mixture 12 is separated therefrom by the primary separator(s) 30, and practically all of the remaining liquid in the wet gas 28 exiting the primary separator(s) 30

is removed by the secondary separators 50. Both the oil/liquid 26 removed by the primary separator 30 and the oil/liquid 29 removed by the secondary separator 50 are returned by gravity into a lower portion of the pressure vessel 14 forming a liquid inventory 31 therein. The high separation capacity of the primary and secondary separators 30, 50 allows for use of a single pair of primary and secondary separators if necessary, as shown in the embodiment of Figure 3. As mentioned earlier, the single primary/single secondary separator arrangement would typically be sufficient to satisfy most subsea applications and thus facilitates design optimization and confirmation testing at prototypic conditions described in greater detail later.

[0017] As illustrated in Figures 1 and 5, each curved-arm, centrifugal force, primary separator 30 comprises a riser tube 32 for conveying the well head fluids mixture 12 upwardly therethrough, four sets of multilayered curved-arms 34, and an outer can or return cylinder 36 surrounding the riser tube 32 and the curved-arms 34. As indicated earlier, the curved-arms 34 of the primary separator(s) 30 are not of the re-entrant type disclosed in the aforementioned US Patent No. US-A-4 648 890; the curved-arms 34 are instead just attached to the outside wall of the riser tube 32. The wellhead fluids mixture 12 enters at the bottom of the riser tube 32 and flows upwardly therethrough until reaching the vicinity of the curved-arms 34, where it exits the riser tube 32. The majority of the oil/liquid separation from the wellhead fluids mixture 12 occurs as the mixture 12 flows through the curved-arms 34, the denser oil/liquid 26 in the mixture 12 tending towards the outer walls of the curved-arms 34. During the centrifugal separation process, a film of oil/liquid 26 develops on the inner wall of the return cylinder 36 and cascades down to the main liquid inventory 31 (Figure 1). The return cylinder 36 extends above the top of the curved-arms 34 where there are a number of perforations 38, preferably about 12.7 mm (1/2 inch) in diameter, and a retaining lip 40 at an open top 42 of the separator 30, which are used to improve the liquid removal capabilities of the separator 30 at high gas and liquid flows, and especially where slug conditions can exist. Various perforation geometries may be employed. The wet gas 28 exits the open top 42 of the primary separator(s) 30 into a substantially open interstage region 44 which is used to distribute the wet gas 28 more evenly prior to its entering the secondary cyclone(s) 50. This interstage region 44 also permits liquid droplets to fall out by gravity when the wet gas flow 28 is below the droplet entrainment threshold. To ensure that the export gas 20 is as dry as possible, a required spacing distance 46 (Figure 5) is maintained between the primary separators 30 and the secondary separators 50, preferably at approximately 1.2 m (4 feet).

[0018] A separation distance 48 is also maintained between the top of the multi-layered curved-arms 34 and the open top 42 of the primary separator 30, and preferably ranges from approximately 380 mm to 460 mm (15 to 18 inches). Liquid removal capacity can be increased by extending this distance.

[0019] As the two-phase wellhead fluid mixture 12 flows out through the curved-arms 34, separation occurs as the heavier oil/liquid droplets 26 migrate to the outer radius of the curved-arms 34 and the less dense wet gas 28 migrates to the inner radius of the curved-arms 34. Separation in the curved-arms 34 allows for an oil/liquid film 26 to be cleanly discharged onto the inner diameter of the return cylinder 36. The retaining lip 40 and perforations 38 are important at high wellhead fluids mixture 12 flows because the retaining lip 40 restricts the growth of the oil/liquid film 26 upwardly while the perforations 38 remove the separated oil/liquid 26 from the inside of the return cylinder 34 allowing it to return by gravity along the outside of the return cylinder 36 to become a part of the oil/liquid inventory 31. After flowing through the primary separator 30, the majority of the separated oil/liquid 26 spirals downwards on the inner diameter of the return cylinder 36 and combines with the liquid inventory 31 in the pressure vessel 14. The wet gas 28 and any remaining entrained oil/liquid droplets 29 enter the secondary separator 50 where the oil/liquid 29 is centrifugally separated from the wet gas 28. The separated oil/liquid 29 is returned to form a part of the liquid inventory 31 via the drain tube 52 and the liquid-free vapour or export gas 20 exits the pressure vessel 14 as shown in Figure 1.

[0020] The primary separator 30 has several advantages. The first is that the majority of the separation processes occur at the curved-arms 34. This makes the process inherently capable of accommodating a wide range of flow and level conditions and minimizes the potential for gas entrainment and resultant swelling in the inventory 31 of the pressure vessel 14. Another advantage is that the relatively large flow passages of the curved-arms 34 essentially eliminate the risk of pluggage since there are no narrow gaps which could attract deposits. The result is a low-pressure drop, high performance primary separator 30 that will have a long life of maintenance-free service.

[0021] The secondary separator 50 also operates on the principle of centrifugal separation. The wet gas 28 enters the secondary separator 50 through tangential inlet vanes 54 at the bottom of the secondary separator 50 which impart a centrifugal motion to the wet gas 28. Any liquid remaining in the wet gas 28 is then forced to the inner wall of the secondary separator 50 where it is separated by secondary skimmer slots 56, exits through a secondary outlet 57, and spills into a secondary compartment 58 (Figure 1). The secondary separator(s) 50 would typically be inserted through and supported by a plate 60, to which would also be connected drain tubes 52. Bypass holes 62 are placed in a top plate 64 of a tertiary compartment 59 to allow gas bypassing through the secondary skimmer slots 56 to exit the tertiary compartment 59 and enhance the skimming action. The separated oil/liquid 29 then drains via the drain tube 52 back

into the lower portion of the pressure vessel 14 and becomes a part of the main pressure vessel's liquid inventory 31. The drain tube 52 isolates the returning separated oil/liquid 29 from the upflowing wet gas flow 28 and avoids the re-entrainment of the separated oil/liquid 29 by the upflowing wet gas 28.

[0022] The centrifugal force cyclone, secondary separator 50 has an inherent advantage over scrubber or mesh type dryers. Both scrubber and mesh type dryers are limited in flow capacity by the droplet entrainment threshold, beyond which liquid droplets are entrained with the vapour and are carried therewith. The centrifugal force cyclone, secondary separator 50, on the other hand, can efficiently operate at vapour fluxes typically two to three times higher than the droplet entrainment threshold.

[0023] Figure 3 illustrates a second embodiment of the present invention which comprises a single pair, centrifugal, gas/oil separator apparatus 70, for subsea applications. In this embodiment, the pressure vessel 14 is supported and partially contained by a pipe or conduit 72 partially embedded within a seabed 74. The pressure vessel 14, as shown in Figure 4, includes a radial, side wellhead fluid inlet 76 for providing the wellhead fluids 12 into the vessel 14 as well as an oil/liquid export outlet 78 for conveying the separated oil or liquids 24 out of the pressure vessel 14 and a gas export outlet 78 for conveying the separated gases 20 from the pressure vessel 14. The height 82 between the export gas outlet 80 and the top of the conduit 72 is preferably approximately 1.5 m (5 feet). The height 84 of the return cylinder 36 is dependent on inventory and level control requirements.

[0024] Figure 6 illustrates the performance characteristics of a single-module centrifugal separator pair in a steam/water environment. The results from a steam/water test at 880 psia test pressure were used for conservatively estimating gas/oil separator performance. These estimates suggest that a single centrifugal separator pair (one primary and one secondary separator) can effectively separate over 43,000 barrels per day (BPD) of oil and over 20 million standard cubic feet per day (20,000,000 SCFD or 20 MMSCFD) of gas for high pressure (approximately 100 psia) applications and over 34,000 BPD oil and 15 MMDCFD gas for low pressure (approximately 250 psia) applications. The peak production for a typical water driven 10-well field is around 25,000 BPD and 14 MMSCFD.

[0025] The advantageous features of the present systems are noted and summarized below:

1 One unique feature is the use of centrifugal-type separators for both the primary and secondary stages of separation. Other separator arrangements typically rely on gravity or inertial separation, which is limited in flow capacity by the droplet entrainment threshold beyond which liquid droplets are entrained with the vapour and are carried downstream. In contrast, the secondary separator of the present system is a centrifugal-type separator which can efficiently operate at vapour fluxes significantly higher than the entrainment threshold.

2 The compactness of the present systems is also advantageous. The separation envelope needed for a single-module, centrifugal gas/oil separator arrangement is approximately 1.2 m (4 feet) long by 0.6 m (2 feet) in diameter. Additional drum or pressure vessel 14 volume may be required to satisfy other system parameters such as inventory demands and liquid level control requirements. A pump 86 for pumping separated liquids and a provision for removing sand 90 from the liquid inventory 31, such as a sand separator or pump schematically indicated at 88, may be incorporated into the gas/oil separator arrangement 70 for certain applications as shown in Figure 3.

3 Another feature of the present system is the manner in which the centrifugal forces are generated in the primary separator 30. The centrifugal force develops as the mixture turns 90° out of the riser tube 32 and flows out through the curved-arms 34. This feature allows the two-phase wellhead fluids mixture 12 to enter the pressure vessel 14 through either a lower axial inlet to the riser tube 32 (Figure 1) or through a side, radial inlet to the riser tube 32 (Figure 3) providing design flexibility for introducing the wellhead fluids 12 into the gas/oil separator arrangements 10, 70. Other known separator designs used for gas/oil applications rely on a radial or tangential inlet into the primary separator to create the centrifugal forces.

[0026] The compact, high-efficiency, gas/oil separator arrangements 10, 70 offer several advantages when compared to the known designs. These advantages include a high vapour capacity, a compact arrangement, and maintenance-free characteristics of the separation equipment.

[0027] Another advantage is that the primary and secondary centrifugal separators 30, 50 have no moving parts and no small passages. This eliminates the potential for hardware pluggage and provides for reliable, long-term, maintenance-free operation, which is extremely beneficial for subsea gas/oil separation applications where accessing the equipment for unplanned maintenance has proven to be very costly.

[0028] The compactness of the present systems provides economical advantages because of the reduced capital to initially fabricate the unit and because of reduced space requirements and/or lifting capacity required to install the equipment topside or subsea.

[0029] While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from the scope of the invention

as defined in the appended claims.

Claims

1. Apparatus for separating an oil/liquid phase from a gas phase contained in a wellhead fluid from a hydrocarbon production system, the apparatus comprising:

   a vessel (14) capable of pressurization and having a wellhead fluid inlet (16) for connection to the hydrocarbon production system, for entry of wellhead fluid (12), a gas export outlet (18) for exit of export gas (20) separated from the wellhead fluid, and an oil/liquid export outlet (22) for exit of oil/liquid (24) separated from the wellhead fluid;
   a main oil/liquid inventory compartment (31) at a lower end of the vessel (14), the oil/liquid export outlet (22) communicating with the inventory compartment (31), a secondary compartment (58) at an upper end of the vessel, and means (52) for connecting the inventory and secondary compartments (31, 58) to each other;
   a primary centrifugal separator (30) in the vessel (14) for separating a majority of the oil/liquid phase from the wellhead fluid (12) to leave a wet gas phase, the primary centrifugal separator (30) comprising a riser tube (32) with an open lower end communicating with the wellhead fluid inlet (16) for receiving upwardly flowing wellhead fluid (12), the riser tube (32) having a closed upper end, a plurality of curved-arms (34) spaced around the riser tube (32) for causing a majority of the oil/liquid phase to separate from the wellhead fluid (12) to leave the wet gas phase, each curved-arm (34) having an axially extending curved wall, curving away from the riser tube (32) between a root edge of the curved wall at the riser tube (32) and an outer edge of the curved wall spaced outwardly from the riser tube (32), at least one radial partition in the curved-arm (34), for dividing an inner space defined by the curved-arm (34) into multiple levels, the primary centrifugal separator (30) also comprising a return cylinder (36) around the riser tube (32) and curved-arms (34), for receiving oil/liquid phase moving outwardly by centrifugal force from the outer edge of the curved-arms (34), the return cylinder (36) having an open lower end extending into the inventory compartment (31) for carrying the oil/liquid phase downwardly to the inventory compartment (31), the return cylinder (36) having an open upper end for passing the wet gas phase; and
   a secondary centrifugal separator (50) in the vessel (14) spaced above and axially aligned with the primary centrifugal separator (30) by an open interstage region (44), the secondary centrifugal separator (50) receiving the wet gas phase and comprising a plurality of tangential inlet vanes (54) into which the wet gas phase passes for further separating oil/liquid from the wet gas phase to leave a dry gas phase, the secondary centrifugal separator (50) including skimmer means (56) defining skimmer slots above the inlet vanes (54) for receiving the dry gas phase and for channelling the further separated oil/liquid downwardly into the secondary compartment (58), the further separated oil/liquid passing from the secondary compartment (58) to the inventory compartment (31) through the means (52) for connecting the inventory and secondary compartments (31, 58), the skimmer means (56) having an open upper end (57) communicating with the gas export outlet (18) for passing the dry gas phase to the gas export outlet (18).

2. Apparatus according to claim 1, wherein the return cylinder (36) includes a plurality of perforations (38) therearound, above the riser tube (32).

3. Apparatus according to claim 2, wherein a portion of the return cylinder (36) which carries the perforations (38) above the riser tube (32), is approximately 380-460 mm high.

4. Apparatus according to claim 1, claim 2 or claim 3, wherein the open upper end of the return cylinder (36) has a radially inwardly extending lip (40), the open upper end (57) of the skimmer means (56) also having a radially inwardly extending lip.

5. Apparatus according to any one of the preceding claims, including a lower support plate (60) extending across the vessel (14) between the inlet vanes (54) and the skimmer means (56), the support plate (60) defining a lower boundary of the secondary compartment (58), the means (52) for connecting the inventory and secondary compartments (31, 58) comprising a tube opening into the support plate (60) and extending to the inventory compartment (31).

6. Apparatus according to claim 5, including a top plate (64) spaced above the support plate (60) and extending across the vessel (14) above the skimmer means (56), the open upper end of the skimmer means (56) extending through the top plate (64) and at least one hole (62) in the top plate (64) for receiving any separated oil/liquid passing above the top plate (64), through the top plate (64) for return to

the inventory compartment (31).

7. Apparatus according to any one of the preceding claims, wherein the oil/liquid export outlet (22) extends through a side of the vessel (14) at a lower end of the vessel (14) which communicates with the main oil/liquid inventory compartment (31).

8. Apparatus according to claim 3, wherein the distance (46) between the upper end of the skimmer means (56) and the lower end of the curved-arms (34) is approximately 1.2 m.

Patentansprüche

1. Vorrichtung zur Abtrennung einer Öl/Flüssigkeitsphase von einer Gasphase, die in einem Bohrlochkopffluid aus einem Kohlenwasserstoffproduktionssystem enthalten ist, mit:

   einem Behältnis (14), das unter Druck gesetzt werden kann und einen Bohrlochkopffluideinlaß (16) zur Verbindung mit dem Kohlenwasserstoffproduktionssystem für einen Eintritt von Bohrlochkopffluid (12), einen Gasaustrittauslaß (18) für den Austritt von Auslaßgas (20), das von dem Bohrlochkopffluid abgetrennt wurde, und einen Öl/Flüssigkeitsaustrittsauslaß (22) zum Austritt von Öl/Flüssigkeit (24), die von dem Bohrlochkopffluid abgetrennt wurden, hat,

   einem Öl/Flüssigkeits-Hauptspeicherabteil (31) an einem unteren Ende des Behältnisses (14), wobei der Öl/Flüssigkeitsaustrittsauslaß (22) mit dem Speicherabteil (31), einem Sekundärabteil (58) am oberen Ende des Behältnisses und einer Einrichtung (52) zur Verbindung des Speicherabteils und des Sekundärabteils (31, 58) miteinander in Verbindung steht,

   einer Primärzentrifugentrenneinrichtung (30) in dem Behältnis (14) zur Abtrennung eines Hauptteils der Öl/Flüssigkeitsphase von dem Bohrlochkopffluid (12), um eine feuchte Gasphase zurückzulassen, wobei die Primärzentrifugentrenneinrichtung (30) ein Steigrohr (32) mit einem offenen unteren Ende hat, das mit dem Bohrlochkopffluideinlaß (16) zur Aufnahme von aufwärts strömendem Bohrlochkopffluid (12) in Verbindung steht, das Steigrohr (32) ein geschlossenes oberes Ende hat, mehrere gekrümmte Arme (34) im Abstand voneinander um das Steigrohr (32) angeordnet sind, um einen Hauptteil der Öl/Flüssigkeitsphase dazu zu bringen, sich von dem Bohrlochkopffluid (12) abzutrennen, um die feuchte Gasphase zu hinterlassen, jeder gekrümmte Arm (34) eine sich axial erstreckende gekrümmte Wand hat, die von dem Steigrohr (32) weg zwischen einer Fußkante der gekrümmten Wand an dem Steigrohr (32) und einer Außenkante der gekrümmten Wand im Abstand nach außen von dem Steigrohr (32) gekrümmt ist, wenigstens eine radiale Trennwand in dem gekrümmten Arm (34) vorgesehen ist, um einen inneren Raum zu teilen, der durch den gekrümmten Arm (34) in mehrere Höhen geteilt ist, die Primärzentrifugentrenneinrichtung (30) auch einen Rücklaufzylinder (36) um das Steigrohr (32) und die gekrümmten Arme (34) umfaßt, um durch Zentrifugalkraft von der Außenkante der gekrümmten Arme (34) sich nach außen bewegende Öl/Flüssigkeitsphase aufzunehmen, der Rücklaufzylinder (36) ein offenes unteres Ende hat, das sich in das Speicherabteil (31) erstreckt, um die Öl/Flüssigkeitsphase abwärts zu dem Speicherabteil (31) zu tragen, und der Rückstromzylinder (36) ein offenes oberes Ende für den Durchtritt der feuchten Gasphase hat, und

   einer Sekundärzentrifugentrenneinrichtung (50) in dem Behältnis (14) im Abstand oberhalb der und axial ausgerichtet mit der Primärzentrifugentrenneinrichtung (30) durch einen offenen Zwischenbereich (44), wobei die Sekundärzentrifugentrenneinrichtung (50) die feuchte Gasphase aufnimmt und mehrere tangentiale Einlaßflügel (54) umfaßt, in welche die feuchte Gasphase für weitere Abtrennung von Öl/Flüssigkeit von der feuchten Gasphase zur Hinterlassung einer trockenen Gasphase geht, die Sekundärzentrifugentrenneinrichtung (50) eine Abschäumeinrichtung (56) einschließt, die Abschäumschlitze oberhalb der Einlaßflügel (54) begrenzt, um die trockene Gasphase aufzunehmen und weitere abgetrennte Öl/Flüssigkeit abwärts in das Sekundärabteil (58) zu lenken, die weiter abgetrennte Öl/Flüssigkeit von dem Sekundärabteil (58) zu dem Speicherabteil (31) durch die Einrichtung (52) zur Verbindung des Speicher- und Sekundärabteils (31, 58) geht und die Abschäumeinrichtung (56) ein offenes oberes Ende (57) in Verbindung mit dem Gasaustrittsauslaß (18) hat, um die trockene Gasphase zu dem Gasaustrittsauslaß (18) zu führen.

2. Vorrichtung nach Anspruch 1, bei der der Rücklaufzylinder (36) mehrere Perforationen (38) um ihn herum oberhalb des Steigrohres (32) hat.

3. Vorrichtung nach Anspruch 2, bei dem ein Teil des Rücklaufzylinders (36), welcher die Perforationen

(38) oberhalb des Steigrohres (32) trägt, etwa 380 bis 460 mm hoch ist.

4. Vorrichtung nach Anspruch 1, Anspruch 2 oder Anspruch 3, bei der das offene obere Ende des Rücklaufzylinders (36) eine radial nach innen sich erstreckende Lippe (40) hat, wobei das offene obere Ende (57) der Abschäumeinrichtung (56) auch eine radial sich nach innen erstreckende Lippe hat.

5. Vorrichtung nach einem der vorausgehenden Ansprüche mit einer unteren Trägerplatte (60), die sich quer zu dem Behältnis (14) zwischen den Einlaßflügeln (54) und der Abschäumeinrichtung (56) erstreckt, wobei die Trägerplatte (60) eine untere Grenze des Sekundärabteils (58) definiert und die Einrichtung (52) für die Verbindung des Speicherabteils und des Sekundärabteils (31, 58) ein Rohr umfaßt, das in der Trägerplatte (60) mündet und sich zu dem Speicherabteil (31) erstreckt.

6. Vorrichtung nach Anspruch 5 mit einer oberen Platte (64) im Abstand oberhalb der Trägerplatte (60) und sich quer zu dem Behältnis (14) oberhalb der Abschäumeinrichtung (56) erstreckend, wobei das offene obere Ende der Abschäumeinrichtung (56) sich durch die obere Platte (64) und wenigstens ein Loch (62) in der oberen Platte (64) erstreckt, um abgetrennte Öl/Flüssigkeit, die oberhalb der oberen Platte (64) passiert, durch die obere Platte (64) zur Rückkehr zu dem Speicherabteil (31) aufzunehmen.

7. Vorrichtung nach einem der vorausgehenden Ansprüche, bei der der Öl/Flüssigkeitsaustrittsauslaß (22) sich durch eine Seite des Behältnisses (14) an einem unteren Ende des Behältnisses (14) erstreckt, welches mit dem Öl/Flüssigkeits-Hauptspeicherabteil (31) in Verbindung steht.

8. Vorrichtung nach Anspruch 3, in der der Abstand (46) zwischen dem oberen Ende der Abschäumeinrichtung (56) und dem unteren Ende der gekrümmten Arme (34) etwa 1,2 m ist.

Revendications

1. Appareil pour séparer une phase huile/liquide d'une phase gazeuse contenues dans un fluide de tête de forage provenant d'un système de production d'hydrocarbures, l'appareil comprenant :

   une cuve (14) adaptée à une pressurisation et comportant une entrée de fluide de tête de forage (16) pour connexion au système de production d'hydrocarbures, pour l'entrée de fluide de tête de forage (12), une sortie d'exportation de gaz (18) pour la sortie de gaz d'exportation (20) séparé du fluide de tête de forage, et une sortie d'exportation d'huile/de liquide (22) pour la sortie d'huile/de liquide (24) séparés du fluide de tête de forage ;

   un compartiment principal de charge d'huile/de liquide (31) à une extrémité inférieure de la cuve (14), la sortie d'exportation d'huile/de liquide (22) communiquant avec le compartiment de charge (31), un compartiment secondaire (58) à une extrémité supérieure de la cuve, et un moyen (52) pour relier les compartiments de charge et secondaire (31, 58) l'un à l'autre ;

   un séparateur centrifuge primaire (30) dans la cuve (14) pour séparer une majorité de la phase huile/liquide du fluide de tête de forage (12) afin de laisser une phase gazeuse humide, le séparateur centrifuge primaire (30) comprenant un tuyau montant (32) avec une extrémité inférieure ouverte communiquant avec l'entrée de fluide de tête de forage (16) pour recevoir le fluide de tête de forage (12) s'écoulant vers le haut, le tuyau montant (32) comportant une extrémité supérieure fermée, une pluralité de bras courbés (34) espacés autour du tuyau montant (32) pour amener une majorité de la phase huile/liquide à se séparer du fluide de tête de forage (12) afin de laisser la phase gazeuse humide, chaque bras courbé (34) comportant une paroi courbée s'étendant axialement, se courbant loin du tuyau montant (32) entre un bord de base de la paroi courbée au tuyau montant (32) et un bord externe de la paroi courbée espacé vers l'extérieur du tuyau montant (32), au moins une cloison radiale dans la paroi courbée (34), pour diviser un espace interne défini par le bras courbé (34) en niveaux multiples, le séparateur centrifuge primaire (30) comprenant également un cylindre de retour (36) autour du tuyau montant (32) et des bras courbés (34), pour recevoir la phase huile/liquide se déplaçant vers l'extérieur sous l'effet de la force centrifuge depuis le bord externe des bras courbés (34), le cylindre de retour (36) comportant une extrémité inférieure ouverte s'étendant dans le compartiment de charge (31) pour transporter la phase huile/liquide vers le bas jusqu'au compartiment de charge (31), le cylindre de retour (36) comportant une extrémité supérieure ouverte pour faire passer la phase gazeuse humide ; et

   un séparateur centrifuge secondaire (50) dans la cuve (14) espacé au-dessus de, et aligné axialement avec, le séparateur centrifuge primaire (30) par une région intermédiaire ouverte (44), le séparateur centrifuge secondaire (50) recevant la phase gazeuse humide et comprenant une pluralité d'ailettes d'entrée tangentiel-

les (54) dans lesquelles la phase gazeuse humide passe pour séparer davantage l'huile/le liquide de la phase gazeuse humide afin de laisser une phase gazeuse sèche, le séparateur centrifuge secondaire (50) comprenant un moyen d'absorption (56) définissant des fentes d'absorption au-dessus des ailettes d'entrée (54) pour recevoir la phase gazeuse sèche et pour canaliser l'huile/le liquide davantage séparés vers le bas dans le compartiment secondaire (58), l'huile/le liquide davantage séparés passant du compartiment secondaire (58) au compartiment de charge (31) via le moyen (52) pour relier les compartiments de charge et secondaire (31, 58), le moyen d'absorption (56) comportant une extrémité supérieure ouverte (57) communiquant avec la sortie d'exportation de gaz (18) pour faire passer la phase gazeuse sèche jusqu'à la sortie d'exportation de gaz (18).

2. Appareil selon la revendication 1, dans lequel le cylindre de retour (36) comprend une pluralité de perforations (38) tout autour, au-dessus du tuyau montant (32).

3. Appareil selon la revendication 2, dans lequel une partie du cylindre de retour (36) qui porte les perforations (38) au-dessus du tuyau montant (32), a une hauteur d'environ 380 à 460 mm.

4. Appareil selon la revendication 1, la revendication 2 ou la revendication 3, dans lequel l'extrémité supérieure ouverte du cylindre de retour (36) comporte un rebord s'étendant radialement vers l'intérieur (40), l'extrémité supérieure ouverte (57) du moyen d'absorption (56) comportant également un rebord s'étendant radialement vers l'intérieur.

5. Appareil selon l'une quelconque des revendications précédentes, comprenant une plaque de support inférieure (60) s'étendant en travers de la cuve (14) entre les ailettes d'entrée (54) et le moyen d'absorption (56), la plaque de support (60) définissant une limite inférieure du compartiment secondaire (58), le moyen (52) pour relier les compartiments de charge et secondaire (31, 58) comprenant une ouverture de tube dans la plaque de support (60) et s'étendant jusqu'au compartiment de charge (31).

6. Appareil selon la revendication 5, comprenant une plaque supérieure (64) espacée au-dessus de la plaque de support (60) et s'étendant en travers de la cuve (14) au-dessus du moyen d'absorption (56), l'extrémité supérieure ouverte du moyen d'absorption (56) s'étendant à travers la plaque supérieure (64) et au moins un trou (62) dans la plaque supérieure (64) pour recevoir toute quantité d'huile/de liquide séparée passant au-dessus de la plaque supérieure (64), à travers la plaque supérieure (64) pour retour jusqu'au compartiment de charge (31).

7. Appareil selon l'une quelconque des revendications précédentes, dans lequel la sortie d'exportation d'huile/de liquide (22) s'étend à travers un côté de la cuve (14) à une extrémité inférieure de la cuve (14) qui communique avec le compartiment principal de charge d'huile/de liquide (31).

8. Appareil selon la revendication 3, dans lequel la distance (46) entre l'extrémité supérieure ouverte du moyen d'absorption (56) et l'extrémité inférieure des bras courbés (34) est d'environ 1,2 m.

FIG. 2

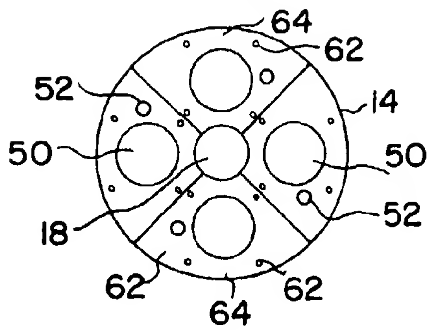
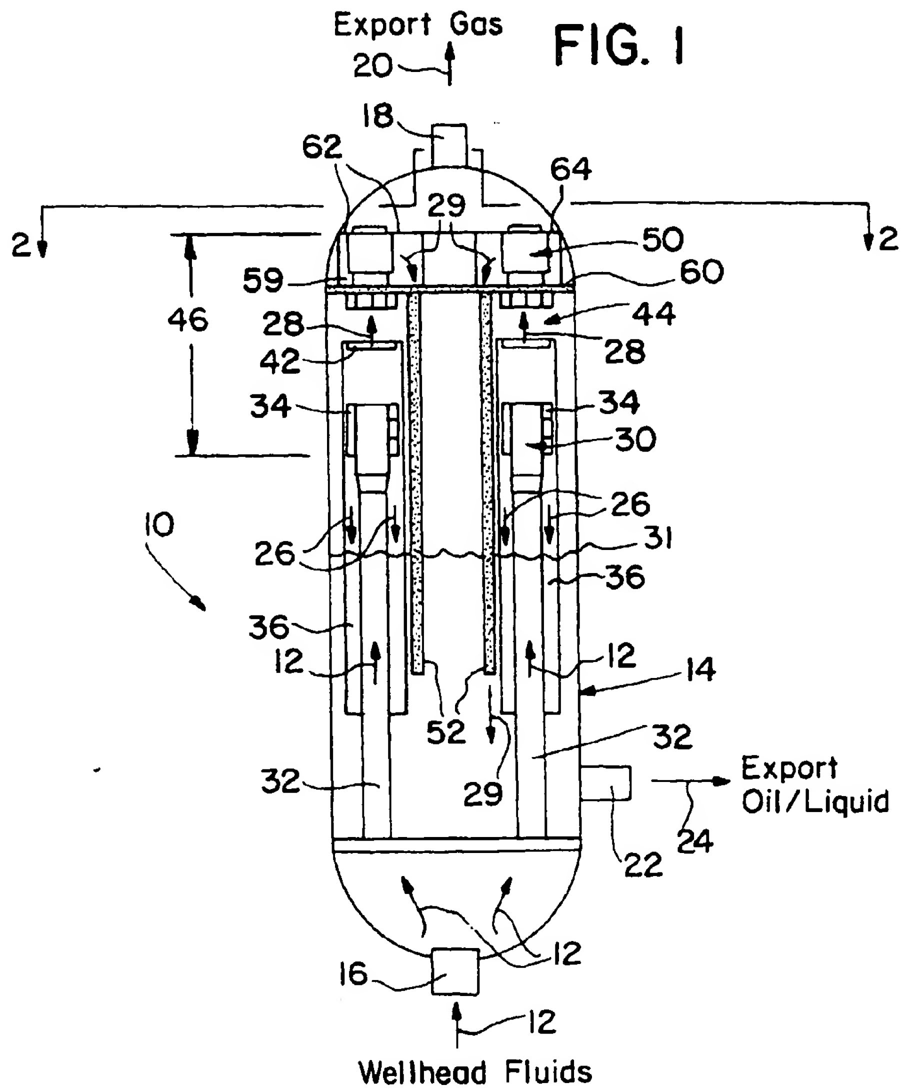

64
62
52
14
50
50
18
52
62
62
64

FIG. 1


Export Gas
20
18
62
64
29
2
2
50
59
60
46
28
44
42
28
34
34
30
10
26
26
31
36
36
12
12
14
52
32
32
29
Export
Oil/Liquid
24
22
12
16
12
Wellhead Fluids

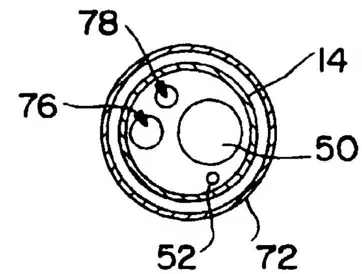

78
76
14
50
52
72

FIG. 4

FIG. 3

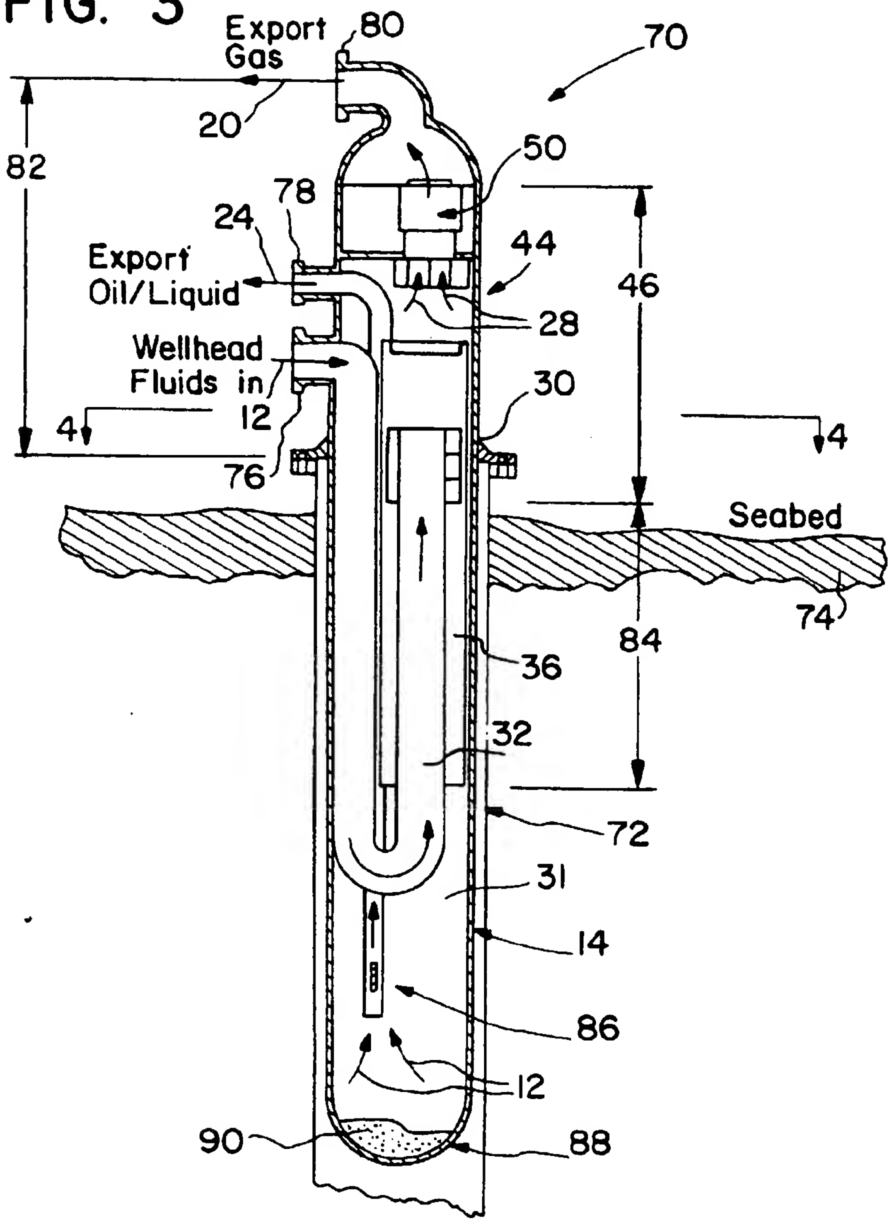

Export Gas
80
70
20
82
50
78
24
Export Oil/Liquid
44
46
28
Wellhead Fluids in
12
30
4
4
76
Seabed
74
84
36
32
72
31
14
86
12
90
88

FIG. 5

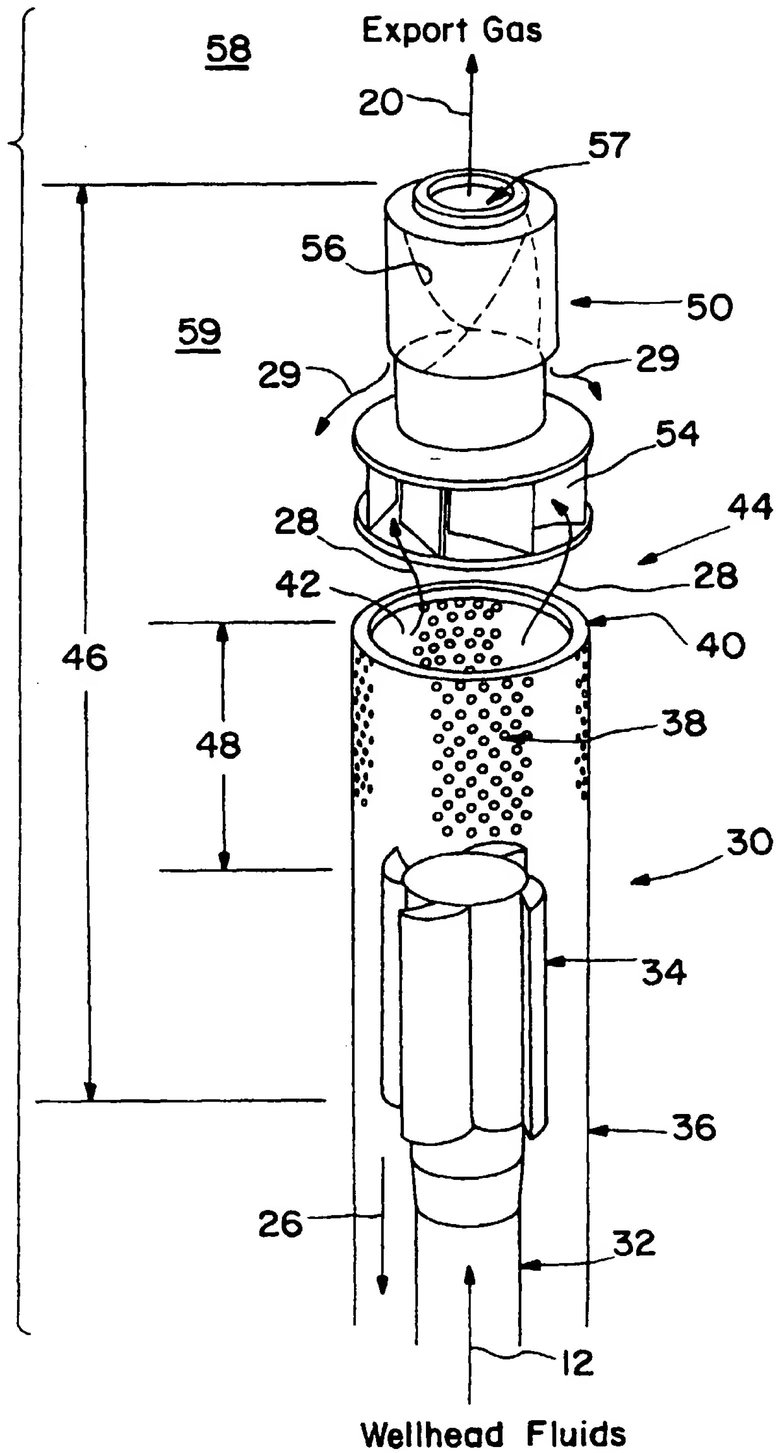
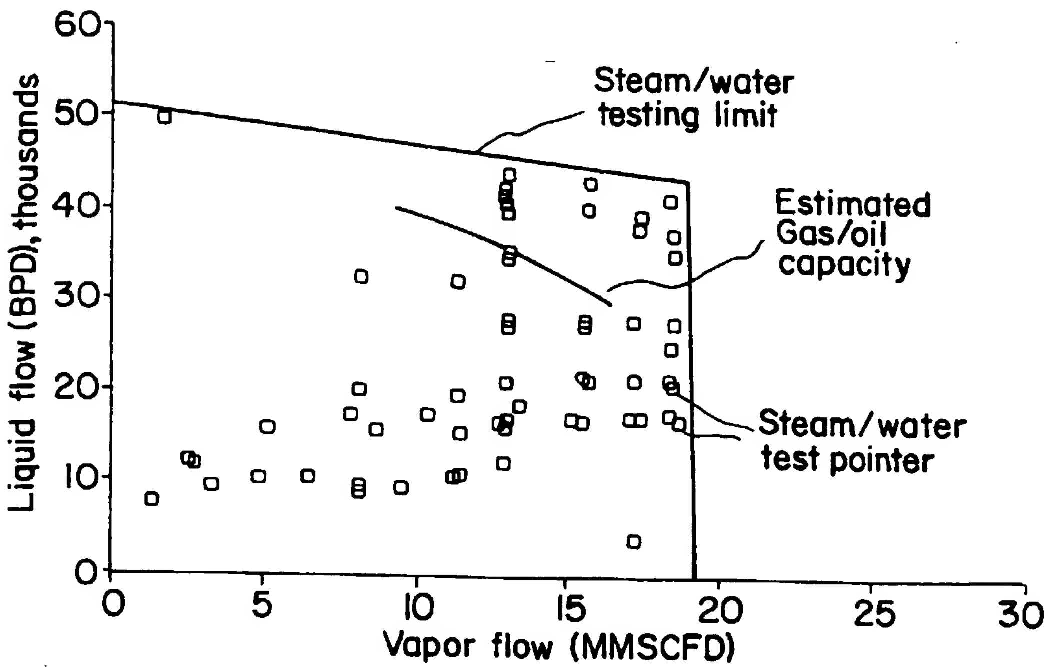

58
Export Gas
20
57
56
50
59
29
29
54
28
44
28
42
40
46
38
48
30
34
36
26
32
12
Wellhead Fluids

FIG. 6


60
50
40
30
20
10
0
Liquid flow (BPD), thousands
0
5
10
15
20
25
30
Vapor flow (MMSCFD)
Steam/water
testing limit
Estimated
Gas/oil
capacity
Steam/water
test pointer